

SECTION 8.0

FISH HABITAT

8.1 INTRODUCTION

The fish habitat assessment for the Acme Watershed Analysis was conducted in accordance with level 2 methodology suggested in the WFPB manual (Version 2.1). The majority of field data were collected during August 1994. Requests for information were mailed to regional and state representatives of the Washington Department of Fish and Wildlife (WDFW), the Nooksack Tribe and the Lummi Nation. Interviews of regional state and tribal fisheries biologists were conducted. The WARIS and DNR water type databases were consulted for information on fish-bearing streams. State Salmon and Steelhead Stock Inventory (SASSI) data were reviewed for information on stock status.

The South Fork Nooksack River originates on the southern flanks of Mt. Baker and flows in a westerly direction approximately 39 miles before meeting the Nooksack River near Deming. From this confluence, the Nooksack River flows another 36.5 miles to Bellingham Bay. The Acme WAU is comprised of approximately 23,000 acres near Acme, Washington and includes the lowermost 13 river miles (RM) of the South Fork Nooksack River and all tributaries below RM 10. Named tributaries include Jones, McCarty, Standard, Hardscrabble, Sygitowicz, Caron, Toss and Tinling Creeks and the Black Slough.

This report is organized into three sections. The first section reviews existing conditions of fisheries resources in the Acme WAU and conditions affecting the resource throughout the Nooksack Basin. Included are discussions of salmonid distribution and abundance, a review of management influences and a brief review of the SASSI records. The second section describes fisheries habitat and relevant aspects of channel morphology in the WAU. The discussion is divided into discrete lifestages, including upstream migration, spawning and incubation, summer rearing and winter rearing. Existing conditions affecting each lifestage are described as well as natural and land management influences on habitat. Level of confidence for the assessment is provided in a final section.

8.2 FISH DISTRIBUTION AND ABUNDANCE

Fish habitat in the WAU can be roughly divided into three major classes; mainstem (South Fork Nooksack River, Channel Segment #1), east-west flowing (alluvial fan) tributaries, (Channel Segments #5 and 6) and north-south flowing (terrace and floodplain) tributaries (Channel Segment #4). Existing habitat conditions have been altered significantly over the past approximately 100 years (Section 6.6 and Section 8.5). Although historically the mainstem South Fork Nooksack River probably provided a greater quantity and quality of spawning and rearing habitat, current use is primarily as a passage corridor to spawning habitat upstream. Only minor chinook, coho, pink and chum spawning activity is now reported in the lower mainstem. Native spring chinook now spawn primarily in the mainstem river above RM 24. Steelhead spawning

has not been observed in the mainstem, in part because of poor water visibility during the spring spawning season.

The Skookum Hatchery, located approximately one river mile upstream of the WAU produces mainly coho smolts with lesser numbers of chinook, pink and chum (CES 1993). Fish often hold in the mainstem at the extreme upper portion of the WAU (near Saxon Bridge) before entering the hatchery (Doug Huddle, WDFW, pers. comm. 1994).

Small numbers of coho, chum and steelhead use many of the tributaries for spawning (WDFW 1975). Fish bearing tributaries with deposits of spawning sized gravels (Segments #5 and #6) are located mainly to the west of the mainstem although several suitable spawning locations are available near the foot of the Van Zandt Dike. These tributaries provide some spawning habitat, with minor numbers of salmon (average less than five pairs of steelhead per year) reported in Sygitowicz, McCarty and Jones Creeks (WDFW 1995, Doug Huddle, WDFW, pers. comm. 1994, Dan Neff, Lummi Nation, pers. comm. 1994). Searun cutthroat trout are also known to use some of the tributaries (WDFW 1994). Resident trout spawning and rearing habitat was noted in all tributaries, but in general was not of particularly high quality, or observed in significant quantities (Section 8.6).

The terrace and floodplain tributaries run approximately parallel (sub-parallel) to the mainstem South Fork Nooksack and have a gradient approximating that of the mainstem (<0.1 percent). These streams offer areas with excellent winter rearing habitat and some spawning opportunities. Toss Creek and Black Slough both provide rearing and spawning habitat. Black Slough in particular offers a network of wetlands and sloughs well suited for overwintering coho.

Resident trout including cutthroat trout (*O. clarkii*) and rainbow trout (*O. mykiss*) are assumed to use all DNR Type 1, 2 and 3 waters. Dolly Varden (or bull trout) have been reported in the S. F. Nooksack (CES 1993). Approximate distribution limits by species are presented in Figure 8-1. Limits were based on DNR water typing maps and modified by results of habitat surveys, fish observations and locations of anadromous fish barriers. Other native resident fish species found in the basin may include dace (*Rhinichthys sp.*), western brook lamprey (*Lampetra richardsoni*), squawfish (*Ptychocheilus oregonensis*), sucker (*Catostomus sp.*), whitefish (*Prosopium sp.*), stickleback (*Gasterosteus aculeatus*), and sculpin (*Cottus sp.*). Non-native species introduced into the area include largemouth bass (*Micropterus salmoides*), brown trout (*Salvelinus fontinalis*), crappie (*Pomoxis sp.*) and bullhead (*Ictalurus sp.*).

DNR water typing information within the Acme WAU generally agreed with information collected during this assessment. One recommendation was made as a result of several fish observations to extend Type 3 waters on Tinling Creek upstream to the pond in the southwest quarter of Section 15. What appeared to be salmonids were observed on three occasions just downstream of the pond. This change, if accepted

by the DNR, would result in approximately 3.5 km of additional Type 3 designated water in the WAU. All modules undertaken for this analysis were completed using the recommended water type change.

No sightings of federally listed, threatened or endangered fisheries species have been described in the WAU in literature reviewed for this analysis, or reported during interviews.

8.3 FISH MANAGEMENT

Salmonid management goals focus on maintaining a viable wild run of anadromous fish while supplementing certain stocks with hatchery production. Particular attention is being paid to the spring chinook and summer steelhead runs. Wild steelhead release regulations are in effect for the entire Nooksack system.

Enhancement

A number of stream habitat enhancement projects have been completed or are planned for the watershed (S. Seymour, WDFW, pers. comm.). Both the State and volunteer citizen groups such as the Nooksack Salmon Enhancement Association are working on salmon enhancement and restoration projects in the Nooksack Basin. Efforts are currently planned to provide additional rearing habitat in Black Slough. Enhancement would include deepening the channel, planting riparian vegetation in bare and suppressed areas, and installation of root wads and other large woody debris (LWD) in the creek.

The Skookum Hatchery, located near the mouth of Skookum Creek approximately one river mile upstream of the WAU, produces mainly coho smolts with lesser numbers of chinook, pink and chum (CES 1993). Many of the fish are released locally.

Recreational Fishery

The Acme WAU supports a popular recreational fishery. The 1994-1995 WDFW sport and game fishing guides indicate statewide catch regulations are in effect, with trout fishing open from 1 June through 15 March. The catch limit is two fish with a minimum size limit of 14 inches. Selective fishery regulations are in effect for all game fish. Wild steelhead release regulations are enforced from 1 June through 31 October. Salmon fishing is permitted from 1 October through 31 December with a daily limit of six including two adults. Minimum size limit is 12 inches.

8.4 SALMON STOCK ORIGIN AND STATUS

The Salmon and Steelhead Stock Inventory (SASSI) is part of a statewide effort to identify distinct anadromous fish stocks and determine their relative health (WDF et al. 1994). Stocks identified as depressed or critical are close to, or below the

population size where permanent loss of distinct genetic material is a risk. The SASSI report defines a stock by the following criteria; 1) distinct spawning distribution, 2) distinct spawning and/or run-timing distribution, and 3) distinct biological characteristics (e.g. genetics, size age structure, etc.). A review of the SASSI report was made to determine whether or not genetically distinct stocks exist in the South Fork Nooksack River.

Chinook

Fall chinook are extremely rare in the South Fork Nooksack system. The non-native stock was originally introduced from the Green River. Insufficient information is available to determine the stock status. Spring chinook are native to the South Fork Nooksack River system and are considered distinct from those found in the North Fork Nooksack. Only minor levels of straying have been detected. Production is considered to be wild although a supplementation program is underway at the Skookum Hatchery. Escapement trends based on data collected since 1984 indicate a chronically low number of fish. The stock status is considered Critical based on the chronically low escapement.

Coho

Nooksack coho are a highly managed stock ranging throughout the entire Nooksack system and tributaries. In addition to a native stock, fish have been imported from the Baker, Skagit, Dungeness, Skykomish and Samish systems. The resultant mélange is considered distinct but mixed. Total releases from the various hatchery and sea pen programs have averaged approximately six million fish between 1982 and 1991. The stock status is considered Unknown due to uncertainties regarding spawner origin.

Chum

South Fork Nooksack chum have been combined with the mainstem Nooksack chum run based on geographical isolation from all other chum stocks. Although Grays Harbor and Hood Canal stock have been introduced at the Nooksack Hatchery, the Mainstem/South Fork stock is still believed to be native. Genetic studies have not been completed. Escapement estimates for the stock have been based on spawning ground counts taken in the North Fork Nooksack. Estimates of natural spawner escapement have ranged from 10,000 to 40,000 between 1982 and 1991. Insufficient drainage specific data is available with which to determine the stock status.

Pink Salmon

Pink salmon have been observed in low numbers in various places of the South Fork Nooksack River. The stock has been tentatively identified as unique based on geographical isolation. No genetic analysis has been completed. Although thought to

be of native origin, an analysis of North and Middle Fork stocks indicated a close similarity to the Hood Canal hatchery stock. Some hybridization may have occurred. Little escapement information is available specific to the South Fork although the numbers are thought to be small in comparison to the other forks. The stock status is Unknown.

Steelhead

South Fork Nooksack steelhead runs have been divided into a summer and winter stock based on geographical isolation of spawning activity. The summer steelhead run is composed of a small number (less than 200 adults) of wild fish. It is the only summer steelhead run in the Nooksack Basin and is thought to be of native origin. The stock is considered to be depressed but the status is listed as Unknown due to inadequate information. All fish are believed to spawn well upstream of the Acme WAU.

The winter steelhead is also believed to be depressed based on a decreasing number of redds observed during surveys of four index areas. The index areas are located in tributaries due to poor water visibility in the mainstem. Uncertainty as to whether the index areas are representative of spawning in the mainstem resulted in an Unknown stock status. Although occasional winter steelhead smolt introductions have occurred, the stock is considered native and distinct. Steelhead spawning is known to occur in the Acme WAU (S. Foley and D. Huddle, WDFW, pers. comm.).

8.5 HISTORIC FISH HABITAT CONDITIONS

Substantial evidence exists to indicate fisheries habitat in the Acme WAU was historically very different than what is found today (Section 6.6.1). Human caused disturbances related to increased agricultural use of the area (farming, ranching) have probably been responsible for the majority of change to fish habitat. Approximately 110 years of LWD removal, bank stabilization (diking), flood control, wetland draining and slough filling have significantly reduced the quality and quantity of available fish habitat. Logging activity in the Acme WAU and upstream throughout the rest of the South Fork Basin further contributed to reduced long term LWD input to the stream system and perhaps increased water temperatures. Natural events including fire, floods and mass wasting also affected fish habitat, but probably to a lesser degree.

Descriptions of the South Fork Nooksack and its floodplain immediately prior to Euro-American settlement portray a typical western Washington "old-growth" system. The mainstem South Fork Nooksack consisted of a strongly meandering, morphologically diverse channel including side channels and associated sloughs (Iverson 1885) (Figure 6-11). River spanning log jams were reported "nearly every mile" with "many million feet of sound fir timber" clogging the river (Morse 1883, Sedell and Luchessa 1981). A swamp approximately 1 mile wide and 2.6 miles long, covering 1,260 acres, occupied the vicinity of the present Black Slough. This swamp contained about 80

acres of open water (sloughs). The river valley also contained several smaller slough channels. The swamp and most sloughs were located outside of the main channel meander belt. Many secondary channels were present and tributaries commonly followed these channels for part of their course across the floodplain. Abandoned side channels contained flow from tributaries or were fed by groundwater.

The mainstem river likely contained numerous deep pools where log jams and other obstructions had scoured holes in the substrate. These pools probably provided excellent summer holding habitat for salmonids (Nooksack Spring Chinook Technical Group [NSCTG] 1987) and helped maintain low stream temperatures (Sedell and Swanson 1984). The abundant LWD also likely served to trap and stabilize coarse sediment thereby increasing the availability of spawning habitat in the WAU (Botkin et al. 1994).

Large debris piles in mainstem channels can deflect high flows into the adjacent landscape eroding side channels and creating backwater pools in the floodplain. These off-channel areas can provide highly productive fish habitat (Sedell et al. 1982). Juvenile salmon, and in particular coho salmon, utilize these areas during high winter flows. As winter approaches and stream temperatures drop, most coho move out of the mainstem and seek refuge in protected tributaries and side channels (Sandercock 1991). In higher gradient systems, juvenile coho may migrate tens of kilometers downstream in search of suitable winter rearing habitat (Scarlett and Cederholm 1984). The extensive side channel and slough system in the Black Slough is unique to the high gradient South Fork Nooksack system and was probably an important winter rearing area.

The mountain slopes supported old, large conifers (chiefly hemlock and Douglas-fir), while the valley bottom supported a mosaic of hardwood, mixed and coniferous forests (Iverson 1885). A fire occurred shortly before 1885 and burned most of the western side of the WAU.

The quantity and quality of fish habitat in the WAU began to decline as increasing numbers of people settled in the lower South Fork Nooksack basin (Section 6.6.2). Early settlers cleared trees from the floodplains and drained wetlands for agricultural purposes. Wood was removed from the rivers for commercial use or burned to minimize bank erosion and flooding during high flows (D. Huddle, WDFW pers. comm.). Diking along the mainstem helped further reduce bank erosion. Logging began on the upper slopes throughout the South Fork Basin.

By 1938, the river had straightened significantly (Figure 6-11). Some meanders had been removed and a number of minor side channels had disappeared. Major logjams had been cleared from the river. Nearly all of the valley bottom had been logged and a considerable area of wetlands had been drained for agricultural use; about half of the swamps present in the 1885 survey had ceased to exist.

As LWD was removed and the banks were diked, channel sinuosity of the mainstem decreased resulting in a decrease in the overall length of the channel (Section 6.6.2). As the channel length shortened, the overall gradient increased. Sediment probably coarsened somewhat (decreased fine sediment levels) as the channel gradient increased. Straightening of the mainstem and draining of wetlands and sloughs was likely accompanied by a lowering of the watertable under the floodplain. Dewatering of slough channels, and reduced exchange between groundwater and the stream (i.e., a reduced hyporheic zone) would have resulted in a reduction of available fish habitat and increased water temperatures.

Currently, very little of the floodplain is now forested with conifers or contains trees more than 50 years old. The river has been further straightened (Figure 6-12) and is now diked over much of its length. There is only a small remnant of the original Black Slough left, and virtually all side channels have ceased to exist. Many streams on the floodplain and alluvial fans are now dry in summer and few have significant shade or woody debris. Summer water temperatures in the mainstem frequently exceed state water quality standards. Calculations for the channel module showed a reduction in the length of the South Fork Nooksack of 37 percent; a reduction in the length of slough channels of 86 percent; a decrease in the length of riparian forest by 35 percent; and a decrease in the total area of channels and gravel bars of approximately 40 percent (Section 6.6.2, Figure 6-14).

Alterations of the South Fork Nooksack over the last century would have adversely affected salmonid habitat in the WAU by removing instream cover, filling pools, reducing scour pools, decreasing side channel and off channel rearing area, reducing spawning sediment availability and increasing stream temperatures.

8.6 EXISTING FISH HABITAT ANALYSIS

Fish habitat surveys were conducted in August 1994. Twenty 300-meter survey sites in fish bearing streams were walked (Table 8-1). Several hundred meters of non-fish bearing waters were also inspected to verify DNR water typing. Information regarding fish habitat and usage was collected continuously throughout each survey. Data collection generally followed methodologies recommended in the manual (WFPB 1994) and TFW Ambient Monitoring Protocols (1993). A summary of field data results and habitat diagnostic calls are presented in Table 8-1. Sediment samples were collected with shovels to assess fine sediment proportions in the substrate. Grain size analysis results are provided in Channel Module Figures 6-21 to 6-44.

Physical factors influencing salmonid lifestages were assessed. Channel attributes affecting upstream migration, spawning, summer rearing and winter rearing were noted and described throughout the surveyed portion of the watershed. The data were used to provide an objective assessment of existing habitat conditions. Areas of special concern to fisheries resources are described below by life stage.

	Pool %		Pool Frequency (CW/Pool)		LWD		Pool Depth ¹ (m)			Dom. Sub.	Spawning Gravel Quality	
	Value	Rating	Value	Rating	No. Pieces/CW	Value	Rating	Avg	Max	% > 1m	% < 0.85	Rating
Terhorst	9.5	Poor	3	Fair		3.3	Good	0.26	0.35	0	10.9	Good
Sygitowicz	0	Poor	0	Poor		0.3	Poor	NA	NA	NA	22.1	Poor
Hrdsrabble	0	Poor	0	Poor		0.2	Poor	NA	NA	NA	ND	---
Standard	15.3	Poor	4	Poor		0.8	Poor	0.33	0.50	0	12.9	Fair
McCarty	19.0	Poor	6	Poor		0.4	Poor	0.34	0.52	0	8.5	Good
Jones	0	Poor	0	Poor		0.4	Poor	NA	NA	NA	5.3	Good
Landing Strip	16.7	Poor	86	Poor		0	Poor	0.40	0.40	0	ND	---
Toss	32.9	Poor	9	Poor		0.2	Poor	0.28	0.38	0	30.6 ³	Poor
Van Zandt	83.8	Good	4	Poor		0.8	Poor	1.03	1.50	57	9.4 ³	Good
Blk Slough	100.0	Good	NA ²	Good		0	Poor	1.00	1.00	100	ND	---
Tinling	0	Poor	0	Poor		0	Poor	NA	NA	NA	15.1	Fair
Caron Rd.	14.8	Poor	4	Poor		1.0	Fair	0.19	0.40	0	8.8	Good

¹Measured at low flow.

²Slough qualifies as one large pool.

³Average of two samples.

NA: Not Applicable, the Black Slough qualifies as one large pool, Sygitowicz, Hardscrabble, Jones and Tinling Creeks were dry.

ND: No sediment sample collected in these reaches.

Ratings based on Manual (Version 2.1).

Table 8-1 Summary of field data results and default habitat diagnostic calls (form 9.3).

8.6.1 Upstream Migration

Hinderences to upstream fish migration were considered to be a concern if they were caused or influenced by human activities, and inhibited fish from accessing a significant amount of spawning or rearing habitat. A number of man-made features were visited including culverts and bridges.

Natural barriers to fish migration were identified on most of the tributaries. Locations of absolute fish barriers (falls etc.) are noted on Figure 8-1. Many of these features are located at the extreme upper end or even above fish bearing waters. Rapidly increasing gradients above alluvial fans often effectively stop fish migration before an absolute barrier. No significant amount of fisheries habitat was found upstream of barriers. Portions of streams located on alluvial fans go sub-surface during summer months. Although variable in length, dry reaches may range up to several hundred meters from July through late September or early October. Migration through these reaches is impossible during this period. Only minor beaver activity was noted in the WAU. Although beaver dams are often negotiable by salmon migrating upstream, they can occasionally present a passage problem.

Several major upstream migration concerns were noted in the South Fork Nooksack River within the Acme WAU. Spring chinook, which enter the river as early as July, may suffer from excessive water temperatures and inadequate holding pools (NSCTG 1987). Snorkel surveys conducted in 1986 throughout the lower 34 miles of the mainstem found generally poor conditions with shallow depths and infrequent wood cover (Schuett-Hames et al. 1988). Water temperatures exceeded 21 °C during the survey. Water temperatures were reported as high as 24 °C near Acme during the summer of 1994 (D. Neff, Lummi Nation, pers. comm). The South Fork Nooksack is a popular summer rafting river due to warm water temperatures and the lack of channel obstructions. Several hundred people have been reported floating downstream on summer weekends (D. Huddle, WDFW, pers comm.). The resulting disturbance to the shallow holding areas may further stress migrating spawners.

8.6.2 Spawning and Incubation

Very little salmon spawning activity currently occurs in the WAU. Most fish proceed upstream to spawning habitat in the upper basin, or to the Skookum Hatchery just upstream of the WAU. Spawning habitat in the WAU is located primarily on the alluvial fans (Segment 5), just downstream of the fans (Segment 6) or in the mainstem South Fork Nooksack (Segment 1). Spawning surveys in the WAU have been conducted in the mainstem, Toss Creek, Black Slough, Sygitowicz, Hardscrabble, McCarty, Jones and one unnamed Creek (WDF 1995). All species have been reported in the mainstem, with coho also observed in Toss, Black Slough, McCarty and Jones Creeks, chum observed in Toss Creek, and steelhead in Sygitowicz, McCarty and Jones Creeks. Coho, chum and steelhead likely use other tributaries in addition to those noted above. Likely areas of use are noted on Figure 8-2.

Several reports have suggested spawning habitat in the area is limited by excessive fine sediment in the substrate (Schuett-Hames and Schuett-Hames 1984, NSCTG 1987, Schuett-Hames et al. 1988). Scouring in the mainstem is also mentioned (NSCTG 1987, Neff 1992) as well as channel instability, high water temperatures and poaching (NSCTG 1987). Schuett-Hames et al. (1988) collected sediment samples in the mainstem South Fork Nooksack near Acme in 1986. Fine sediment levels ranged from approximately 6 to 16 percent with an average of 10 percent. Four of the five samples were less than 11 percent. Fine sediment levels were very similar in samples collected from the mainstem upstream of the WAU for this analysis.

Sediment samples were collected from potential spawning habitat throughout the WAU to assess the proportion of fine sediment ($<0.85\text{mm}$). Fine sediments levels in excess of 12 percent are generally believed to have a detrimental effect on salmonid egg and juvenile survival to emergence (Cederholm et al. 1980, WFPB 1994). Samples were removed with a shovel and stored in a plastic bag for transport. Grain size analysis was done using the wet sieving techniques described in the TFW Ambient Monitoring Program Manual (1993). Results are presented in Table 8-1 and further described in the channel module (Section 6.7.3).

Fine sediment composition of spawning gravel on the alluvial fans was generally low (5-13 percent), except for Sygitowicz Creek where two samples found 20 percent (pool tailout) and 22 percent (riffle) fine material. High fines may be the result of ravelling in landslide scars left from multiple mass wasting sites in the upper sub-basin. Fine sediment levels in the slough channels were considerably higher ranging from 5 to 31 percent with an average of 19 percent. These channels were formed on fine sediments deposited by the Nooksack and would be expected to have high fine sediment levels. Four samples collected from various places along the mainstem ranged from 5 to 15 percent with an average of 12 percent. These result are very similar to those reported by Schuett-Hames et al. (1988) indicating little change over the last eight years. Fine sediment levels were probably even higher during pre-settlement times. Lower gradients in combination with increased LWD should have resulted in increased sedimentation rates for fine materials (Section 6.6.4).

Spawning habitat was probably more abundant in the past. Anthropogenic activities (logging and LWD removal) have depleted the amount of LWD throughout the WAU. Fall and winter flows move rapidly down channels with few obstructions (LWD, boulders) available to slow velocities and stabilize gravels in spawnable riffle and pool tailout configurations (Section 6.4). Loss of LWD and bank stabilization activities have decreased channel diversity and sinuosity. Spawning substrate deposition behind debris jams and along meander bends has decreased. Increased channel gradient in the mainstem has likely resulted in a larger average substrate size (Section 6.4). Recent sliding in the 1970's and 1980's led to aggradadation and loss of LWD in many of the mountain tributary basins. Subsequent degradation resulted in unstable conditions poorly suited for spawning or rearing. Additional LWD could help stabilize

spawning gravels and decrease the magnitude of spawning habitat quality variations associated with dynamic sediment supply rates.

Spawning and incubation information on Figure 8-2 indicates areas where salmon spawning activity has been reported in recent years. Habitat quantity and quality in most areas is poor. A discussion of each area is provided below by species.

Chinook

South Fork Nooksack chinook spawn primarily in the mainstem river upstream of the Acme WAU. Chinook redds have been observed within the WAU with the majority noted at the upstream end above RM 8.6. The Skookum Hatchery located immediately upstream of the WAU also collects returning chinook.

Coho

Coho spawn in limited numbers in all suitable streams in the WAU. Spawning surveys conducted by the WDFW and others indicate most spawning activity was concentrated in the tributaries. A large number of fish return each year to the Skookum Hatchery.

Pink

Little information is available describing pink salmon use of the WAU. Mainstem spawning surveys in 1989 found several hundred fish at the extreme upstream end of the WAU. The lower section was not surveyed that year but previous surveys have recorded redds in the first several miles of the mainstem. Pink salmon have not been reported using any of the tributaries (WDF 1975).

Chum

Chum salmon spawn in low numbers in the mainstem and suitable tributaries throughout the WAU. Adult chum have been reported using the Black Slough and McCarty, Tinling and Jones Creeks (WDF 1975). Spawning surveys have also noted chum in Toss Creek.

Steelhead

Steelhead spawn in the mainstem and higher gradient tributaries (Channel Segments 1, 5 and 6). These tributaries provide some spawning habitat, with minor numbers of steelhead (average less than five pairs per year) reported in Sygitowicz, McCarty and Jones Creeks (Doug Huddle, WDFW, pers. comm. 1994, Dan Neff, Lummi Nation, pers. comm. 1994). Overall steelhead use of the entire South Fork Nooksack system is estimated to be less than approximately 200 fish per year with most spawning above the WAU (WDF et al. 1994).

Sea-run Cutthroat

Sea-run cutthroat migrate into the Acme WAU during February through April and spawn in early spring. Spawning typically takes place in the steep upper reaches of tributaries, in some cases above the upper extent of salmon spawning (Doug Huddle, WDFW, pers. comm. 1994). Feeder tributaries to the Black Slough have been noted as important sea-run cutthroat spawning areas. Some of the steeper western tributaries to the South Fork Nooksack (ie. Sygitowicz, McCarty) are also believed to provide limited spawning habitat.

Resident Trout

Resident trout spawn throughout all Type 1 through 3 waters in the WAU. Patches of suitable gravel were observed in most areas surveyed. The best spawning habitat conditions were observed on the alluvial fan sections of the western tributaries (Segments 5 and 6). The mainstem also provides some resident trout spawning habitat.

8.6.3 Summer Rearing

Habitat surveys conducted in August 1994 examined a number of variables affecting summer rearing habitat in the Acme WAU. The more important factors are discussed below and are shown on Figure 8-3. Criteria under consideration included pool quantity and frequency, pool depth, LWD frequency, percent woody cover and water temperature.

Summer rearing concerns noted in the literature (NSCTG 1987, Schuett-Hames et al. 1988) focus primarily on water quality issues. The South Fork Nooksack below Skookum Creek has been designated a water quality limited reach by the Washington State Department of Ecology (WDOE 1994). Listing was based on possible impacts of fine sediments on fish habitat. The reach immediately upstream of the WAU was listed based on excessive stream temperatures as well as fine sediment concerns. It is reasonable to assume high temperatures measured upstream continue through into the Acme WAU since only minimal riparian shading is present along the mainstem and groundwater influence has been severely reduced (Section 7.3). In fact, water temperatures in the mainstem were reported as high as 24 °C near Acme during the summer of 1994 (D. Neff, Lummi Nation, pers. comm).

Six temperature gaging stations were installed in the WAU between 4 August and 27 September 1994 (Section 9.4.1). This period did not encompass a much warmer period during late July 1994. Peak temperatures recorded at several locations exceeded the 18-20 °C level where sub-lethal effects on salmonids begin to occur (Barnhart 1986, Raleigh et al. 1986). The highest peak temperature (21.5 °C) was recorded in the mainstem near the Saxon Bridge. Temperatures equalling or exceeding 18 °C were also recorded on the mainstem Nooksack (RM 40.8) (18 °C) and

Hardscrabble Creek (21 °C). Complete results are presented in the Public Works Section (9.4).

The stream temperature portion of the Riparian Module (Section 7.3) evaluated several variables influencing water temperature in the streams. The current degree of canopy closure over fish bearing waters was found to be "adequate" on only 12 percent of the WAU. Loss of LWD in the channel, draining of the sloughs and wetlands, and a general lowering of the water table in the WAU were also cited as evidence of anthropogenic influences contributing to increased stream temperatures over past undisturbed conditions. Summer rearing habitat in the majority of fish bearing water in the WAU are probably degraded by excessively warm stream temperatures for at least part of the summer. Cooler refuge habitat which often occurs in pools has probably been reduced by the loss of LWD (Sedell and Swanson 1984).

Increased suspended sediment loads (turbidity) can have detrimental effects on fish communities and benthic invertebrates upon which fish feed. Effects of high sediment loads include lower primary production (reduced food supply), reduced ability to find prey, physiological changes (excessive mucus secretion, excretory interference), interference with respiration (clogged and abraded gills) and even death (Laufle et al. 1986). Some species cease feeding and seek cover in response to increased turbidity levels. Other species outmigrate looking for clearer water. Turbidity effect differs by species, lifestage, length of exposure and sediment type.

Coho cease feeding at turbidity levels above 300 mg/l but maintain position at levels of 4,000 mg/l. Cutthroat quit feeding and moved to cover at 35 mg/l (Bachman 1959). Rainbow trout suffered 57 percent mortality at 1,000 mg/l over 20 days (Campbell 1954), while chinook experienced only 12 percent mortality at approximately 5,000 mg/l (Smith 1940). Coho presmolts and smolts suffered 50 percent mortality at turbidity levels of 1,217 and 509 mg/l respectively after 4 days (Stober et al. 1981). A turbidity of 20,000 mg/l or greater was found to be an acute lethal concentration for salmonids (Sorenson et al. 1977).

Turbidity was noted as a concern for juvenile rearing in the South Fork Nooksack by the Nooksack Spring Chinook Technical Group (1987) although no data was referenced. Neff (1993) collected a single sample following a 1.4 inch freshet from the South Fork Nooksack at the upstream edge of the WAU (RM 12.9). The sample had a turbidity level of 180 NTU (nephelometric turbidity units) which is sufficient to affect salmon use of a stream (Sigler et al. 1984). The Skookum Hatchery has also reported turbidity levels high enough to halt juvenile feeding (Neff 1993). Insufficient direct evidence was collected during this watershed analysis to address the effect of land use and management in the WAU on turbidity levels. High turbidity levels reported in the mainstem are present as the river enters the WAU however, and therefor are a result of processes outside of the Acme WAU. Evidence collected for the Surface Erosion module (Section 4.0) indicated the WAU does not contribute high amounts of fine sediment to fish-bearing streams.

Extreme summer low flow problems are experienced where many of the tributaries traverse the alluvial fans. Dry reaches were observed in Tinling, Todd, Sygitowicz, Hardscrabble, Standard, McCarty, Jones and Landing Strip Creeks. As channels dry up during the summer, a significant amount of habitat becomes unavailable to fish. Isolated pools may remain but are likely inferior rearing locations due to water quality, temperature and predation concerns. Fish stranded in the pools or upstream of the dry reaches may not survive the summer. Large increases in sediment supply in recent history have aggraded the depositional area of the fans (Section 6.5.2). As sediment depth increased, the amount of flow travelling sub-surface also increased. Some of the channels are currently degrading under low sediment supply conditions (Section 6.9). If these conditions continue, surface flow could be expected to increase over time.

Both the percentage and frequency of pool habitat are low throughout the WAU (Table 8-1). The only tributaries surveyed with good ratings were two slough channels on the eastern floodplain (Van Zandt and Black Slough). The channels were deep enough in most areas to qualify as a pool. Pools in the WAU were typically controlled by LWD (Figures 6-19 and 6-20). The low pool frequency might be explained by the lack of LWD. Under historic conditions, the high frequency of LWD probably resulted in a higher pool frequency. Of the 64 pools assessed in the tributaries, 32 (50 percent) were associated with LWD. Bedrock, boulders and scouring at channel bends also formed pools.

Large woody debris counts found low numbers of functional pieces in almost all segments surveyed (Table 8-1). LWD counts within the 12 habitat survey units found ten units with a relatively low abundance of wood (< 1 piece per channel width), one (near Caron Road) was rated fair (1-2 pieces/cw) and one (Terhorst) was rated good (> 2 pieces/cw). Areas with low LWD are shown on Figure 9-3. LWD counts were probably more abundant in the past than what is observed now (Section 7.2). Stream cleaning, debris flows and recent large flood events have removed a significant amount of in-channel wood from the streams (Section 6). The analysis of future LWD recruitment indicates 83 percent of the riparian area around fish bearing waters lacks the ability to supply large wood in the near term (Section 7.2.2). Much of the reason can be attributed to the fact that 89 percent of the fish bearing streams traverse lands devoted to agriculture. These lands are covered for the most part with sparse, young, deciduous stands of trees.

Instream cover includes brush, shrubs, pieces of partially submerged wood and any other object overhanging from the shore which provides a visual and/or stream flow barrier for fish. Woody cover is preferred because of it's stability and year-round presence, but grasses also provide some shade benefit during the summer. Juvenile fish in particular use cover to hide from predators and conserve energy. The highest densities of fish in a stream are often associated with areas containing abundant instream cover (Bustard and Narver 1975, Platt 1974). When riparian areas are cleared and not allowed to recover, such as occurs when land is converted to

agriculture or the banks are rip-rapped, salmon habitat is degraded. This was observed in many areas along the mainstem and Black Slough.

Percent of the stream with overhead cover was assessed during the walking surveys and ranged from 0 to 30 percent with an average of about 10 percent. The highest values (20 and 30 percent) were observed at Landing Strip and the Black Slough respectively but consisted almost entirely of grasses. Cover of between 6 and 20 percent of the stream can be considered fair (WFPB 1994).

Salmon Summer Rearing

The Acme WAU contains some areas with good salmon summer rearing habitat in the mainstem (Segment #1) and floodplain tributaries (Segment #4) but nowhere near the quality and quantity which likely occurred under historic conditions. Chinook and coho fry and juveniles prefer shallow (<30 cm) quiet stream reaches such as pools, backwater areas and stream margins (Reeves et al. 1989). Stream gradients less than three percent are normally selected. Glides and riffles with large substrate are used by juveniles but with less frequency than pools (Raleigh et al. 1986). Channel gradients in Segment #1 and #4 average less than 0.1 percent. Most of the stream channels are deep, very slow moving and slough-like. High summer temperatures degrade habitat quality in some areas, in particular the mainstem South Fork Nooksack.

Resident Trout-Steelhead Summer Rearing

Juvenile steelhead and resident trout prefer cool, deep water with moderate velocity and a substantial amount of overhead cover. Summer trout and juvenile steelhead habitat in the WAU is limited by low or no flows in many of the tributaries, and warm water temperatures in other areas (Figure 8-3). Low pool frequencies, shallow water depths, low overhead cover and infrequent LWD all limit the suitability of summer habitat (Table 8-1).

Sea-run Cutthroat

Sea-run cutthroat trout historically used the Black Slough as an important juvenile rearing area (Doug Huddle, WDFW, pers. comm. 1994). The large network of streams provided ample rearing opportunities to spend the first 2 to 3 years of their lives before migrating to saltwater. As the complex was converted to farmland and the deeper areas filled with fine sediment, much of the historic habitat was lost.

8.6.4 Winter Rearing

The selection of winter rearing habitat by salmonids is typically based on finding refuge from high winter flows, flood events and cold temperatures. Variables affecting winter rearing quality include pool quantities and depths, LWD availability, off-channel refuge areas and large, clean interstitial spaces in the substrate. Figure 8-4 shows areas with

the best wintering rearing habitat under current conditions as well as an estimate of winter habitat which may have existed around the time the area was settled by Euro-Americans. Areas with poor pool habitat and inadequate LWD counts are noted on Figure 8-3.

Where available, off-channel meanders, tributaries and sloughs are preferred by overwintering juvenile salmon (Raleigh et al. 1986). Large unembedded substrate and instream structures also provide a means of escape from high flows (Everest 1969). While once abundant in the WAU, off-channel refuge areas are now relatively scarce (Section 6.6.4). Slough channels (Segment #3) and floodplain tributaries (Segment #4) are still present in various areas (Figures 6-12 and 8-4). The Black Slough is a remnant of a once vast slough and associated wetlands complex. A substantial amount of rearing habitat is still available in the lower slough as well as in Toss Creek below Williams Lake. The large log jams and associated debris clogged side channels once noted on the mainstem no longer provide velocity shelter during the winter. Channel straightening has reduced the mainstem to a relatively uncomplicated river. As runoff increases during winter storms, instream flows get deeper and faster rather than spreading out over the adjacent floodplains.

As fine sediment proportions increase in the substrate, juvenile fish lose the ability to seek refuge in the interstitial spaces. Sediment samples from the South Fork Nooksack found approximately 40 percent of the substrate was smaller than 6 mm. Qualitative assessments of substrate in the mainstem indicated embeddedness ranged from approximately 50 to 75 percent. These levels have been shown to result in a decrease in salmon densities, possibly in part due to the loss of winter habitat (Chapman and McLeod 1987, McDonald et al. 1991).

Pool, LWD and cover characteristics of the WAU were discussed under summer rearing.

Coho Winter Rearing

Coho prefer relatively deep calm areas for overwintering habitat (McMahon 1983). Quiet off-channel areas which may dry up during the summer are often preferred winter habitat areas (Narver 1978). Coho overwintering habitat exists primarily in the slough channels (Segment #3) and floodplain tributaries (Segment #4). The lowermost segment of some of the tributaries (Segment #6) may also provide habitat. Historic conditions were probably more abundant and had superior habitat characteristics (Section 6.6).

Resident Trout-Steelhead Winter Rearing

Little is known about juvenile steelhead use of the WAU for winter rearing. Juveniles spawned in the tributaries may be flushed into the mainstem during high winter flows. Because steelhead juveniles are known to prefer higher gradient channels with faster water velocities than other salmon (Barnhart 1986), they may prefer overwintering in the

natal tributaries. Small pools and velocity shelters in the substrate provide some habitat in these areas. Other fish may seek refuge in the slough channels (Segment #3) and floodplain tributaries (Segment #4).

Resident trout information is also scarce. Like juvenile steelhead, they are often found in higher gradient streams and thus may be more vulnerable to high flows. Suitable refuge is probably available in most areas for a small number of fish.

Sea-run Cutthroat

Sea-run cutthroat trout historically used the Black Slough as an important juvenile rearing area (Doug Huddle, WDFW, pers. comm. 1994). The large network of streams provided ample rearing opportunities to spend the first 2 to 3 years of their lives before migrating to saltwater. As the complex was converted to farmland and the deeper areas filled with fine sediment, much of the historic habitat was lost.

8.7 FISH HABITAT VULNERABILITIES

Fish habitat vulnerabilities are derived in conjunction with the channel geomorphologist. Channel segments are evaluated for habitat value by fish lifestage and assessed for potential sensitivity of each reach to degradation from various input variables (coarse and fine sediment, water, LWD, temperature). Those segments deemed sensitive to degradation from a particular input variable, and which contain existing or potential habitat value, are deemed vulnerable to that input. The level of vulnerability (Moderate or High) suggested in Figure 9 in the watershed analysis manual (WFB 1994) may be modified by site-specific considerations. The following section describes fish habitat vulnerability to each input variable.

Coarse Sediment

Debris flows and dam-break floods have the potential to deposit large volumes of coarse and fine sediment, and woody debris, in channels with existing or potential fish habitat (stream segments 5 and 6). Debris flow deposits would bury channel roughness elements (boulders, LWD) and fill pools. Loss of channel obstructions would increase average water velocities, impede scouring of new pools and lessen localized storage of spawning gravels. Sub-surface summer flows may result because of channel aggradation with debris flow deposits.

Fish rear in most channel segments potentially affected by debris flows (fine and coarse sediment). Most habitat lost would occur in tributaries along the western side of the valley. Sub-surface flows are already observed during the summer in many of these streams. Although surface flow would return during winter, the loss of bed roughness could prevent salmonids from finding adequate velocity shelter during high flow events.

Fish habitat is considered highly vulnerable in channel segments susceptible to debris flows scour or deposition. The primary reasons include loss of pool habitat and burial of

bed roughness elements. Fish habitat is considered moderately vulnerable to fluvially transported coarse sediment when sediment thickness is less than the sizes of pool-forming obstructions. For example, bedload moving layers during low- to moderate-sediment supply may be between 0.2 - 0.4 m, and hence this depth of moving bed material should not exceed the sizes of pool-forming obstructions, such as logs and boulders. In contrast, fish habitat is considered highly vulnerable during the passage of coarse- and fine textured sediment waves when aggradation may exceed 0.5 - 1 m. During such high sediment supply events, pool-forming obstructions may be temporarily buried.

Fine Sediment

Debris flows have the potential to deliver large amounts of fine sediment to fish bearing waters (Section 7). In addition, channel aggradation with coarse sediment also can increase levels of fine sediment in gravels. Sediment samples taken from aggradational terraces found the proportion of fine sediments ($<0.85\text{mm}$) increased to as much as 38 percent during periods of high sediment supply (Section 7.7.3). Substrate fines in excess of approximately 12 percent have the potential to degrade spawning and incubation habitat. Suspended sediment can also affect fish habitat depending on the magnitude and duration of its presence in the water column. Neither hillslope or road surface erosion was deemed likely to contribute a chronically high amount of fine sediment to fish habitat in the WAU (Section 5.1.4 and 5.4).

Fish habitat is considered highly vulnerable to fine sediment in channels susceptible to debris flows, or during channel aggradation with fluvially transported coarse sediment (associated with passage of sediment waves). Fish habitat is considered moderately vulnerable to fine sediment in channels not susceptible to debris flows, and when channel aggradation is less than the heights of pool-forming obstructions.

Surface erosion of landslide scars can generate large amounts of fine sediment which may become incorporated into spawning gravels at the mouth of tributaries. Vulnerability of channels to fine sediment is high if landslide scars can increase fine sediment levels to 17% or greater. Measurements of fine sediment in streams indicate that existing landslide scars are not increasing fine sediment to those levels. Because the potential for other forms of surface erosion to deliver fine sediment in sufficient quantity to materially change the resource condition was judged minimal, the assessment team rated habitat vulnerability low in all areas for fine sediment produced by surface erosion.

Temperature

Temperatures exceeding approximately 19°C can have a negative influence on salmonid growth and survival rates. Maximum stream temperatures as high as 24°C have been recorded in the South Fork Nooksack River (Section 9.6.5). Areas most likely to be affected by high temperatures are reaches downstream of channels with deficient riparian tree cover, the Black Slough where decreased exchange rates between ground and surface waters are suspected and the South Fork Nooksack River. Only 16 percent

of surveyed stream reaches met target shade criteria (Section 8.3.2). High stream temperature has the potential to affect fish habitat in all fish-bearing waters.

Fish habitat in channel segments 1, 3, 4, 5 and 6 is considered highly vulnerable to stream temperature increases. These reaches are currently used by both resident and anadromous fish populations for summer rearing. The South Fork is used as a holding area for salmon migrating upstream to spawn.

Large Woody Debris

Large woody debris affects all aspects of fish habitat. Beneficial effects include shelter from high stream velocities, spawning sediment accumulation, gradient modification (pool and riffle forming) and allocthonous material traps. Surveys found low quantities of LWD in nearly all fish-bearing channel segments (Section 9.6.5). Land use practices (logging, agricultural clearing) and dam break floods are believed to be responsible for the reduction of wood. Future recruitment potential is deemed low for the majority (83 percent) of fish-bearing streams (Section 8.2.2); in part because 89 percent of fish-bearing streams in the Acme WAU traverse lands currently devoted to agriculture.

Fish habitat in all fish bearing waters (channel segments 1, 3, 4, 5 and 6) is considered highly vulnerable to LWD. Surveys found a general correlation of pool habitat to LWD throughout the WAU. LWD frequency was below levels believed adequate for fish habitat (Chapter 9). Additional in-channel LWD would be expected to increase habitat availability and quality.

Water

The hydrologic analysis indicated increased peak flows are not likely to cause significant scouring or other channel degrading effects in the WAU. Under existing forest age classes, rain-on-snow peak flow increases are expected to average only 3 to 5 percent higher than for fully forested conditions. This level of increase is probably not detectable, and is not expected to be a significant factor in causing channel instability (Section 6.3). Localized stream reaches below recent headwater clearcuts may experience as much as a 26 percent increase in peak streamflow. Localized channel instability and culvert size inadequacy could be a result. Peak flow increases would rapidly lessen downstream as the relative proportion of the clearcut drainage area upstream diminished. With most fish habitat in the WAU at the downstream end of the sub-basins, it is unlikely these regional clearcuts will cause significant increases in peak flows in fish-bearing channels. Without a channel sensitivity to increases in peak flow, the assessment team concluded fish habitat vulnerability to this input factor was low.

8.8 CONFIDENCE IN WORK PRODUCTS

Overall confidence in the various work products supplied for this module is relatively high. Level two field work conducted for the module included observations of the majority of fish-bearing creeks. The primary focus of the analysis was on forestland. Because of the large number of private/residential lands, not all creeks were surveyed,

and those that were, were limited to short distances. Omissions in the discussion of particular reaches should not be construed as an indication of lack of importance. Habitat types noted on the figures were extrapolated from these data and may vary from reach to reach. A considerable amount of information was also available in the literature. Field data agreed in most cases with conclusions drawn from other studies. Discussions with other module leaders were extensive resulting in unanimous agreement regarding fish habitat problems in the WAU.

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